SOUND REPRODUCTION APPARATUS

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to a sound reproduction apparatus that provides favorable reproduced signals in an environment of relatively high ambient noise.

2. Description of the Related Art

FIG. 6 is block diagram of a conventional sound reproduction apparatus. Referring to FIG. 6, signals supplied to input terminal 1 are led, through a variable gain controller 2, to a power amplifier 3 for power amplification. An output signal from the power amplifier 3 is delivered to a speaker unit 4 mounted on a baffle 5 to be reproduced into sound. Meanwhile, a microphone 6 placed at the vicinity of the speaker unit 4 collects a sum of the signals radiated from the speaker unit 4 and the noise in the neighborhood of the baffle 5.

An output signal from the microphone 6 is delivered, together with the output signal of the power amplifier, to a subtracter 7. The subtracter 7 subtracts input signal components from the sum of the signals radiated from the speaker unit 4 and the ambient noise collected by the microphone 6, in order to extract the ambient noise components. An output signal of the subtracter 7, which is proportional to the ambient noise, is limited to a pass band by a low-pass filter 8. An output signal of the low-pass filter 8 is rectified from AC to DC by a rectifier 9 and then delivered to the variable gain controller 2 provided at the front stage of the power amplifier 3. Thus, the degree of amplifying the input signals is automatically varied by the

variable gain controller 2 in accordance with a degree of ambient noise around the speaker unit 4, so that signals radiated from the speaker unit 4 are not masked by the ambient noise.

In the conventional sound reproduction apparatus, however, there is a difference between the signal components radiated from the speaker unit 4 and the signal components delivered from the power amplifier 3. Therefore, the subtracter 7 can not totally remove the signal components radiated from the speaker unit 4, or, it is difficult to extract the component of the ambient noise around the speaker unit 4. So, it is necessary to perform the control, using only very limited pass band components of the noise.

SUMMARY OF THE INVENTION

The present invention aims to provide a sound reproduction apparatus that precisely removes signals radiated from a speaker unit and varies the gains in accordance with the ambient noise.

A sound reproduction apparatus of the present invention extracts ambient noise components using a first microphone provided outside the dust cap of a speaker unit and a second microphone provided inside the dust cap of the speaker unit. With the above-described arrangement, the ambient noise around the speaker unit can be precisely extracted, and a natural compensation to the masking can be performed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows block diagram of a sound reproduction apparatus in an example of the present invention.

FIG. 2 is an output characteristic of a second microphone in the sound reproduction apparatus of the present invention.

FIG. 3 is an output characteristic of a high-pass filter in the sound reproduction apparatus of the present invention.

FIG. 4 is an output characteristic of a first microphone in the sound reproduction apparatus of the present invention.

FIG. 5 is an output characteristic of a low-pass filter in the sound reproduction apparatus of the present invention.

FIG. 6 shows a block diagram of a conventional sound reproduction apparatus.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows block diagram of a sound reproduction apparatus in an example of the present invention. Referring to FIG. 1, input signal supplied to an input terminal 10 is delivered to a variable gain controller 11, or control means, which is controlled by a signal generated in accordance with an ambient noise to be described later. Output of the variable gain controller 11 is delivered to a power amplifier 12, an output signal of the power amplifier 12 is connected to a speaker unit 14 mounted on a baffle 13. Outside the dust cap of speaker unit 14, a first microphone 16 is provided for collecting the sum of the signal radiated from speaker unit 14 and the ambient noise.

Inside the dust cap of speaker unit 14, a second microphone 17 is provided for collecting the signal in proportion to the sound radiation from speaker unit 14.

An output signal of the first microphone 16 after passing through a low-pass filter 18 and an output signal of the second microphone 17 after

passing through a high-pass filter 19 are input together to an adder 20. Then, components of the signal radiated from the speaker unit 14 are removed, and only the noise components around the speaker unit 14 collected by the first microphone 16 can be extracted. Output of the adder 20, which being the noise components around speaker unit 14, is delivered to a rectifier 21, or conversion means, to be converted from AC signal to DC signal. By supplying output signal of the rectifier 21 to the variable gain controller 11, the gains are automatically varied in accordance with the ambient noise around the speaker unit 14. Thus, the masking is compensated in a more natural way.

In the following, description is made by way of a practical example.

FIG. 2 shows frequency and phase characteristics of the output signal from the second microphone 17 relative to the output signal of power amplifier 12. In FIG. 2, frequency at a phase characteristic 0° is 70Hz. A primary high-pass filter 19 of cut-off frequency 70Hz is set as a second filter for outputting a signal of certain specific pass band. Frequency and phase characteristic of the output signal from the second microphone 17 after passing through the high-pass filter 19 are shown in FIG. 3. Frequency at the phase characteristic 0° is 95Hz.

FIG. 4 shows frequency and phase characteristic of the output signal from the first microphone 16 in relation to the output signal of power amplifier 12. A primary low-pass filter 18 is set as a first filter outputting a signal of certain specific pass band so that phase characteristic is -180° at the frequency 95Hz. Frequency and phase characteristic of the output signal from the first microphone 16 after passing through the primary low-pass

filter 18 are shown in FIG. 5. As shown in FIG. 3 and FIG. 5, output signals from the first microphone 16 and the second microphone 17 have approximately the same band pass characteristic in the frequency and the phase characteristic, with the phase inverse to each other. By inputting these signals to the adder 20, signal components radiated from the speaker unit 14 are removed, only the noise components around the speaker unit 14 collected by the first microphone 16 can be extracted.

Although the first microphone 16 is provided somewhere outside the dust cap 15 in the present example, it may be attached and fixed instead on the outer surface of the dust cap 15. The latter configuration, which does not require any place for installing the first microphone 16 outside the speaker unit 14, is advantageous in a case where space available for installing the speaker unit 14 is limited. Also, the first microphone 16 may be provided in a location opposing the dust cap 15 with a certain predetermined clearance in between. In this case, signals reproduced by the speaker unit 14 and ambient noise may be collected together with a higher fidelity. Thus, the accuracy of extracting the noise components is improved for compensation of the masking.

Although the second microphone 17 is provided somewhere inside the dust cap 15 in the present example, it may be attached and fixed instead on the inner surface of the dust cap 15. The latter configuration, in which the place of second microphone 17 can be away from the inside of the speaker unit 14 where the temperature is increased during operation, is advantageous in that the second microphone 17 is protected from damage due to the heat. Also, the second microphone 17 may be provided so as to oppose the dust cap 15 with a certain predetermined clearance in between. In this case, signals reproduced by the speaker unit 14 may be collected with

a higher fidelity. Thus, the accuracy of extracting the noise components is improved for compensation of the masking.

In the present example, the first microphone 16 and the second microphone 17 have been disposed, respectively, at the outside and at the inside of the dust cap 15. These microphones may be disposed instead on the axial line of the dust cap 15 opposing face to face with the dust cap 15 in the middle. In the above-described configuration, the first microphone 16 collects the signals reproduced by the speaker unit 14 containing the ambient noise, while the second microphone 17 collects the reproduced sound of the speaker unit 14 within the dust cap 15 at an improved accuracy without adversely affecting the sound quality of speaker unit 14. It is advantageous in terms of the quality of reproduced sound and the accuracy of extracting the noise components. Thus, it leads to a higher accuracy in compensating the audio sound masking.

INDUSTRIAL APPLICABILITY

Output signals from the two microphones, disposed respectively at the outside and the inside of the dust cap, are processed through filters for precisely extracting only the ambient noise around the speaker unit, with the signal components output from the speaker unit removed. The noise signal is converted by a rectifier circuit into DC component, and supplied to a variable gain control circuit provided at the input stage for automatically varying the gains in accordance with the ambient noise around the speaker unit. Thus, the sound reproduction apparatus of the present invention provides reproduced sound that is not masked by the ambient noise.